

## Perspectives in Practice

## Food Safety: Emerging Trends in Foodborne Illness Surveillance and Prevention

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## ABSTRACT

Between 250 and 350 million Americans are estimated to suffer acute gastroenteritis annually, with 25% to 30% thought to be caused by foodborne illnesses. Most vulnerable to foodborne diseases are elderly people, pregnant women, immune-compromised people, and children. While bacterial causes such as *Salmonella* are widely recognized and monitored as foodborne infections, other important bacterial causes such as *Clostridium perfringens*, *Bacillus cereus*, and *Staphylococcus aureus* are less well known. While the majority of cases of foodborne diseases are of unknown cause, bacteria and viruses are the most likely causative agents. *Caliciviridae* (Norwalk-like) virus cases are more difficult to identify, but represent the most common cause of known and probably unknown cases. Fresh produce has to be added to the traditional list of foods requiring careful selection and handling to prevent foodborne disease. To assess the disease burden in the United States, morbidity and mortality surveillance activities are done by several networks and systems with collaboration among federal agencies and health departments. Not all important causes are being equally monitored. Critical behaviors by food processors, food retailers, foodservice personnel, and consumers can reduce the risk of foodborne illness episodes. Dietetics professionals can more readily monitor new developments and update knowledge and practice through online resources.

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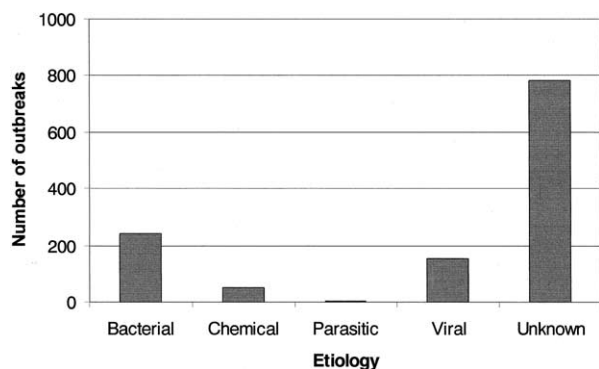
Acute gastroenteritis affects 250 to 350 million people in the United States annually, and an estimated 22% to 30% of these cases are thought to be foodborne disease (1). Approximately one of four Americans may experience some form of foodborne illnesses each year, according to Centers for Disease Control and Prevention (CDC) data (2-5). Widespread media coverage of larger outbreaks has sometimes called into question the safety of the US food supply (1). Questions arise about how the food became unsafe, the actual causes, and how to keep foods safe.

Viruses, bacteria, parasites, and a variety of chemicals are causes of foodborne-disease outbreaks, as shown in Figure 1 (3). Although the causes of many outbreaks reported to the CDC are unknown, the leading known causes are viral and bacterial. The 2003 position paper of the American Dietetic Association emphasizes not only food but also bottled water as sources of foodborne-disease outbreaks (6).

An outbreak is defined as two or more reported cases of foodborne disease with specific criteria for diagnosis, but many individual cases of acute gastroenteritis are not reported and yet impose a substantial burden on the United States (1,5,7). The total annual estimated costs of foodborne-disease outbreaks are thought to be between \$2 billion and \$4 billion (7). Foods consumed in institutions and other foodservices are considered the leading locations for foodborne outbreaks (3). Reasons for this include: epidemiological selection (outbreaks involving several people are more likely to be traced back to the source than are individual cases), lack of quality assurance in foodservices, and failure of employees to follow critical behaviors that mitigate the potential for foodborne illness.

Surveillance mechanisms have been put into place by the CDC and by state and local health authorities to assess the morbidity and mortality of food-related pathogens. Unfortunately, the true burden of illness may go underreported because health professionals fail to recognize some illnesses caused by the less-publicized or emerging organisms. The difficulty in identifying the causative factor leads to underreporting. Additionally, many individuals with acute gastroenteritis do not seek treatment.

The purpose of this article is to review concerns about food safety, including causes of foodborne illnesses in the United States, especially those affecting older Americans, as well as those not widely recognized or publicized. Surveillance methods, emerging techniques, newer organisms, revised guidelines, and practical suggestions for clients, employees, and clinicians are presented for both the healthy and more vulnerable populations.



**Figure 1.** Etiology of food-related illnesses reported to the Centers for Disease Control and Prevention in 2001. [Data from Olsen and colleagues (3).]

### MORBIDITY AND MORTALITY SURVEILLANCE

Mead and colleagues (1), in a seminal piece on the incidence of foodborne illness, used several sources of information to estimate the reported numbers of 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths annually. Sources for this estimation included data from Foodborne Diseases Active Surveillance Network (FoodNet), National Notifiable Diseases Surveillance System (NNDSS), several National Center for Health Statistics (NCHS) databases, and two older population surveys: the Tecumseh (1965-1971) and Cleveland (1948-1957). Many causes are not reportable in either passive or active surveillance systems. Currently, such organisms include noroviruses, *Clostridium perfringens*, *Bacillus cereus*, and *Staphylococcus aureus*. Estimates for the incidence of these nonreportable illness causes were gleaned from historical epidemiological data, and a multiplier was then applied to arrive at the estimate. Although criticized as being either excessive or inadequate (8), the estimates of Mead and colleagues (1) remain the most comprehensive to date.

The 2003 position paper of the American Dietetic Association on food and water safety briefly outlines the five government programs for improvement of food and water safety through surveillance and education (6). These programs were expanded and coordinated under the Food Safety Initiative of the Clinton Administration (6).

### Passive Surveillance

Sources of information for foodborne disease outbreak estimates include passive surveillance systems such as the NNDSS and active systems such as the FoodNet. The CDC collects, analyzes, and summarizes these data.

In the passive NNDSS system, state, territorial, and some local health departments report on the incidence of selected illnesses (9). The incidences are reported in *Morbidity and Mortality Weekly Report* (MMWR) and then summarized at the end of the reporting year. Illnesses or organisms to place in the surveillance are determined yearly through collaboration between the CDC and state health department officials. Of the more than 50 organisms/illnesses listed in 2004, 17 are known to have some association with food.

### National Notifiable Diseases Surveillance System

Botulism	<i>Clostridium botulinum</i> toxin
Brucellosis	<i>Brucella abortus</i>
Cholera	<i>Vibrio cholerae</i>
Cryptosporidiosis	<i>Cryptosporidium parvum</i>
Cyclosporiasis	<i>Cyclospora cayetanensis</i>
Enterohemorrhagic <i>Escherichia coli</i> (EHEC)	<i>E coli</i> O157:H7
EHEC non-O157	<i>E coli</i> serogroup non-O157
EHEC nonserogrouped	
Hemolytic uremic syndrome (HUS post diarrhea)	Likely <i>E coli</i> O157:H7 etiology
Hepatitis A	Hepatitis A
Listeriosis	<i>Listeria monocytogenes</i>
Q-fever	<i>Coxiella burnetii</i>
Salmonellosis	<i>Salmonella</i> serovars
Shigellosis	<i>Shigella</i> species
Trichinosis	<i>Trichinella spiralis</i> and others
Typhoid fever	<i>Salmonella typhi</i>
<b>Foodborne Diseases Active Surveillance Network (FoodNet)<sup>a</sup></b>	
Bacteria	Parasites
<i>Campylobacter</i> species	<i>Cryptosporidium parvum</i>
<i>E coli</i> O157:H7	<i>Cyclospora cayetanensis</i>
<i>L. monocytogenes</i>	
<i>Salmonella</i>	
<i>Shigella</i>	
<i>Vibrio parahaemolyticus</i>	
<i>Yersinia enterocolitica</i>	

**Figure 2.** Food-related pathogens that are included in national surveillance systems. <sup>a</sup>Catchment: states of Connecticut, Georgia, Maryland, Minnesota, New Mexico, Oregon, and Tennessee; selected counties of California, Colorado, and New York. (Data from the Centers for Disease Control and Prevention. Available at: <http://www.cdc.gov/epo/dphsi/nndsshis.htm> and <http://www.cdc.gov/foodnet/>.)

### Active Surveillance

FoodNet is an active surveillance system that coordinates the CDC and 10 state and local health departments (10). The surveillance is actively involved in data collection on seven bacteria and two parasites of emerging or established importance. The catchment for FoodNet is nearly 38 million people. The CDC collects weekly or monthly data from local clinical laboratories and physicians on the incidences of the nine organisms and related illnesses, such as hemolytic uremic syndrome (HUS), associated with *Escherichia coli* O157:H7. FoodNet also surveys for a variety of other foodborne disease outbreak-related factors, including incidence of diarrhea, and is considered one of the most viable monitoring systems for selected foodborne pathogens (4). Organisms that are in these two surveillance systems are shown in Figure 2.

### International Classification of Diseases (ICD) Codes

Data about foodborne-disease outbreaks were also collected from databases maintained by the NCHS (10). Morbidity and mortality data, collected as ICD codes (ICD, 9th Revision, Clinical Modification [ICD-9-CM] or ICD-10, respectively), can be used to determine the incidence related to foodborne disease. Mortality data were collected from death certificates as ICD-9 codes until

Code	Illnesses	Causative organism
001	Cholera	<i>Vibrio cholerae</i>
002	Typhoid	<i>Salmonella typhi</i>
003	Salmonellosis	<i>Salmonella</i> spp. <sup>a</sup>
004	Shigellosis	<i>Shigella</i> spp.
005	Bacterial intoxication food poisoning	
005.0	Staphylococcal food poisoning	<i>Staphylococcus aureus</i>
005.1	Botulism	<i>Clostridium botulinum</i>
005.2	Food poisoning due to <i>C perfringens</i>	<i>C perfringens</i>
005.3	Other clostridia	
005.4	<i>Vibrio parahaemolyticus</i>	<i>V parahaemolyticus</i>
005.8	Other food poisoning	<i>V vulnificus</i> , <i>Bacillus cereus</i>
005.9	Food poisoning unspecified	
006	Amebiasis	Various parasites
007	Other protozoa intestinal diseases	<i>Giardia</i> , <i>Cryptosporidia</i> , <i>Cyclospora</i>
008	Bacterial infection food poisoning	
008.0	<i>Escherichia coli</i> illnesses	<i>E coli</i> EPEC <sup>b</sup> , ETEC <sup>c</sup> , EIEC <sup>d</sup> , EHEC <sup>e</sup>
008.4	Other specified bacteria	<i>Campylobacter</i> , <i>Yersinia</i> , others
008.5	Unspecified bacterial enteritis	
008.6	Enteritis due to specific virus	Rotavirus, Norwalk, others
009	Ill defined intestinal infections	
027.0	Listeriosis	<i>Listeria monocytogenes</i>
070.1	Hepatitis A	
558	Other gastroenteritis of noninfectious origin	

<sup>a</sup>spp.=species.  
<sup>b</sup>EPEC=enteropathogenic *E coli*.  
<sup>c</sup>ETEC=enterotoxigenic *E coli*.  
<sup>d</sup>EIEC=enteroinvasive *E coli*.  
<sup>e</sup>EHEC=enterohemorrhagic *E coli*.

**Figure 3.** International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes for illnesses caused by foodborne pathogens (1).

1999, when the new version, ICD-10, became available. The ICD-10 version has codes for more complete descriptions of foodborne disease based on the specific pathogen involved.

Morbidities associated with foodborne disease are classified in the ICD-9-CM codes listed in Figure 3. Of note are codes 009 and 558.9, codes for ill-defined or other noninfectious gastroenteritis. In the years 1996 to 2000, these two codes had the highest incidence in the areas of food-related gastroenteritis. Although several nonreportable foodborne pathogens are not typically screened for in clinical laboratories, the patient's presentation clearly shows some form of gastroenteritis. Symptoms of an illness may be defined as gastroenteritis without an identifiable cause or vector. Thus, an estimated 250 to 350 million US citizens may have some form of gastroenteritis, with 211 million (60% to 84%) from unknown sources (1). Mortality data for selected known foodborne pathogens are given in Figure 4. Viruses and food infections account for the majority of food-related deaths.

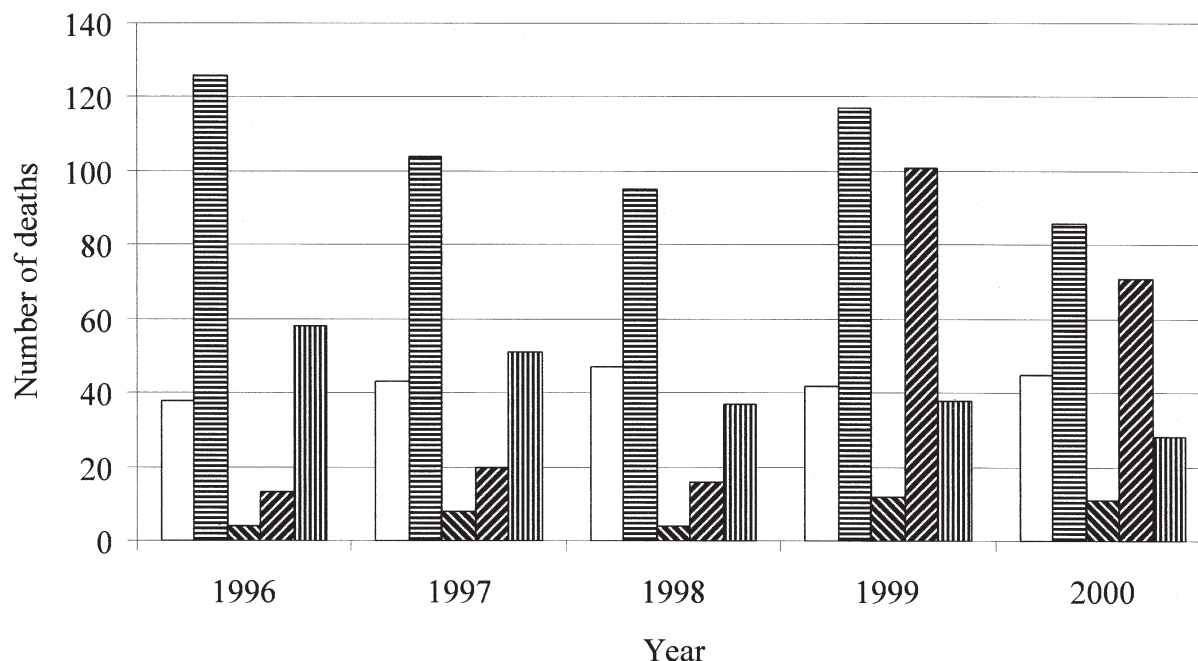
#### Vulnerable Populations

The populations most at risk for foodborne disease and subsequent death are the elderly, pregnant women, immune-compromised individuals, and children, especially children younger than age 5. Figure 5 shows the

proportion of deaths in the population in which decedents were older than age 65 years and ICD-9 or -10 codes were for foodborne disease. For example, 40% of the deaths from *Salmonella enteritidis* were nursing home residents, a finding that reflects the seriousness of this foodborne disease in the immunocompromised and the elderly (3). The majority of people who die from diarrheal illnesses, namely *Salmonella*, viruses, and *Listeria monocytogenes*, are likely to be older than age 65 (3,11,12). Whereas many cases of gastrointestinal distress are short-lived (3 to 5 days), secondary long-term complications may arise that are life threatening and require hospitalization. Acute gastroenteritis and its subsequent dehydration are of particular concern for the senior population and the very young. Included in this set of pathogens are *C perfringens*, Norwalk-like virus, and *B cereus*. Young children are another particularly vulnerable group due to potential for rapid dehydration, limited recognition of thirst, more permeable gut tissue, and less gastrointestinal reserve capacity (13).

#### LESSER KNOWN CAUSES OF FOODBORNE ILLNESS

Basic principles of foodservice sanitation include a discussion of physical, chemical, and biological hazards that may be controlled throughout the processing of foods. Excellent reviews of the nine FoodNet organisms are



**Figure 4.** Mortality ascribed to International Classification of Diseases, 9th Revision (ICD-9) or ICD-10 codes related to foodborne pathogenic organisms. Does not include *Shigella*, cholera, typhoid fever, or parasites. *Listeria*, □; viral, ▨; food intoxications, ▤; food infections (0008+0085), ▩; all *Salmonella*, ▮.

available elsewhere (14,15). The focus here is on organisms that commonly cause foodborne disease, are not frequently reviewed, are not reported in FoodNet, and yet are important for institutional and other foodservices.

### Microorganisms

Whereas the FoodNet organisms are responsible for a significant morbidity and mortality in the United States (16,17), the leading cause of foodborne disease are viruses of the *Caliciviridae* family, more commonly known as Norwalk-like or Noroviruses.

Figure 6 shows contributing factors to foodborne disease as attributed to recognized outbreaks. All are the result of improper food handling behaviors. Improper holding temperature is the leading contributing factor to reported foodborne disease (3). The organisms *C perfringens* and *B cereus* are the ones likely to be associated with temperature abuse of cooked foods. *Caliciviridae* are associated with the improper behavior of poor personal hygiene of food workers.

New organisms continue to be added to the list of potential foodborne disease causes with increased attention to foods not previously considered to be common carriers. For example, a widespread outbreak of *Yersinia pseudotuberculosis* involved 47 cases in Finland and a matched case-control identified iceberg lettuce as the carrier (18). A follow-up investigation traced the source of the contaminated lettuce to be iceberg lettuce grown on four Finnish farms and demonstrated a dose-response to the frequency of which the lettuce was consumed in four cafeterias. Feces from wild deer were considered to be the original source of the organism in the soil that was then

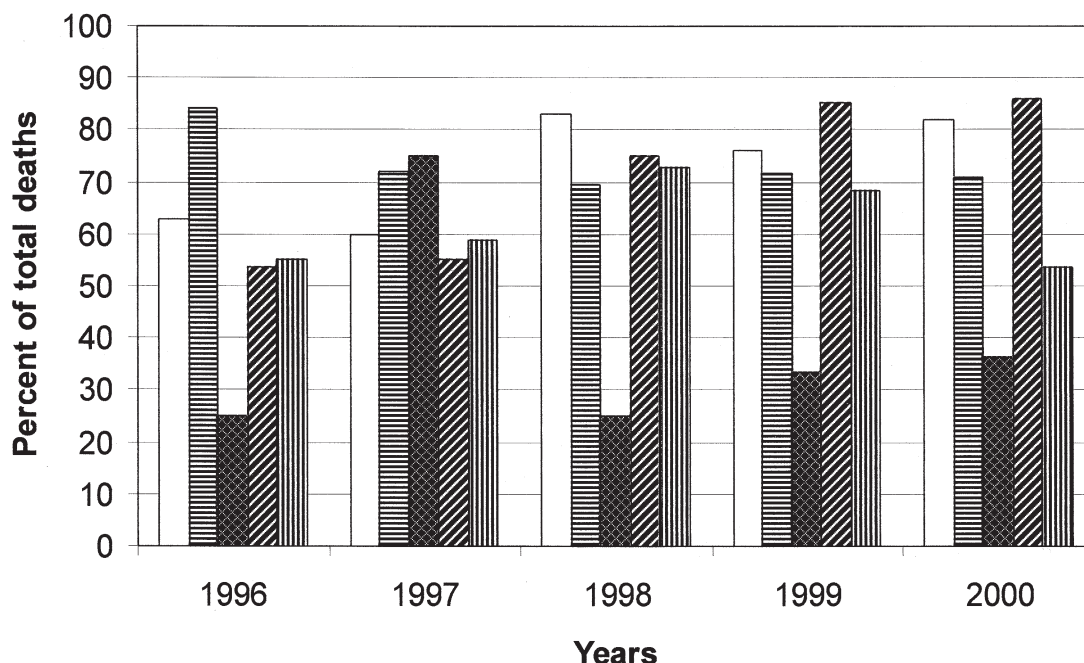
taken systematically into the lettuce. Contaminated water was not found as in other previous foodborne disease outbreaks (18).

In general, cross-contamination of produce and raw meat is more common in produce. An outbreak of *Campylobacter* enteritis involved lettuce cross-contaminated from raw poultry previously cut on the same board (19). These cases reinforce the need for continual vigilance in sanitation of cutting boards and kitchen surfaces, especially with the recognition of *Campylobacter* as a contributing factor in the development of Guillain-Barre Syndrome.

***C perfringens* and *B cereus*.** The leading behavioral causative factor of foodborne outbreaks (not individual illnesses) is improper holding temperatures, which results in the growth of *C perfringens* and *B cereus*. Both organisms cause mild forms of gastroenteritis that may not be reported. These organisms share common characteristics: (a) formation of heat-stable spores, (b) production of enterotoxins that cause gastroenteritis, (c) frequent occurrence in heat-treated foods such as cooked rice or gravy, and (d) same control measures.

***C perfringens*.** *C perfringens* is found widely in the environment and may be a member of the intestinal microflora of humans and animals. Evidence suggests that only a few strains of this organism produce the enterotoxin that induces gastroenteritis (20,21). All strains produce spores; some food-related strains produce spores that can survive most cooking temperatures, including boiling broth. Growth occurs between 20°C and 50°C with the optimum between 37°C to 45°C. In the optimum temperature range and under ideal nutritional conditions (as found in most foods), growth is very fast, with doubling





**Figure 5.** Proportion of total mortality ascribed to International Classification of Diseases, 9th Revision (ICD-9) or ICD-10 codes related to foodborne pathogenic organisms in the population older than 65 years. Does not include *Shigella*, cholera, typhoid fever, or parasites. Listeria, □; viral, ▨; food intoxications, ▤; food infections (0080+0085), ▩; all *Salmonella*, ▮.

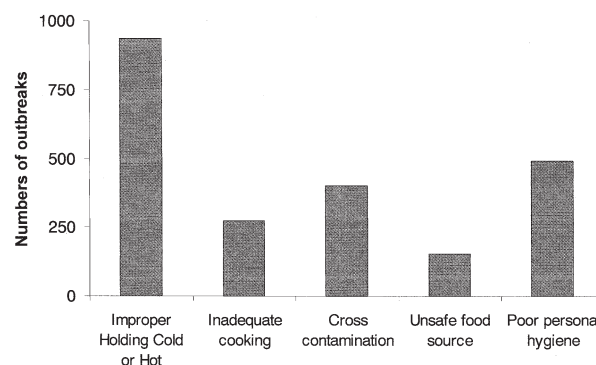
times of 7 to 10 minutes noted. Under stress conditions and in the human gut, the organism forms the spore and enterotoxins are released upon lysis of the cell.

The illness caused by *C perfringens* enterotoxin is short-lived, with diarrhea and abdominal cramps lasting less than 48 hours with onset in 8 to 24 hours (20,21). The enterotoxin effectively reverses intestinal electrolyte and water absorption to cause diarrhea and cramping. Fecal shedding of spores may continue for an indefinite period of time with some people becoming carriers. In 2001, *C perfringens* was the second leading cause of bacterial outbreaks reported to the CDC (22), even though it is not included in either the passive or active surveillance systems. After Norwalk-like virus, it was also the second leading cause of foodborne disease in Minnesota from 1991 to 1998 (23). In most people, the illness is short-lived; however, in the elderly the illness may last for up to 2 weeks. This protracted time of diarrhea and illness may result in failure to retain water, dehydration, and potentially death.

Foods commonly associated with *C perfringens* foodborne disease are cooked meats or poultry stored or held at improper temperatures (20,21). Hot foods left at or near the optimum temperature range for growth promotes growth of the organism to the high numbers required for illness. Slow cooling of hot foods also allows growth of the organism to pathologic levels. Outbreaks are typically associated with holding foods in steam tables at temperatures below 60°C (140°F) and trying to cool large boluses of foods. Temperatures less than 21°C (70°F) slow the growth of the organism; hence, the 2001 Food and Drug Administration (FDA) Food Code recommends that foods be cooled to this temperature in less than 2 hours and then to 5°C (41°F) in 4 more hours (24).

***B cereus*.** *B cereus* is widespread throughout the environment in soil, milk, water, and plant material including spices. The organism produces a very heat-stable spore that will survive in boiling water (25). *B cereus* grows at temperatures less than 4°C (40°F) and up to 55°C (131°F), although growth at these extremes is very slow. Psychrotrophic strains of *B cereus* can be found in milk and dairy products after surviving pasteurization (26). The optimum temperature ranges are similar to those for *C perfringens*. The foods most likely to be implicated in *B cereus* poisoning include cooked meats and vegetables, cooked milk products, and cereals including cooked rice and pasta.

Pathologic strains of the organism produce one of two types of toxins: emetic or diarrheagenic. Both toxins are produced by actively growing cells with the emetic toxin



**Figure 6.** Contributing factors to foodborne outbreaks from 1993-1997. [Data from Olsen and colleagues (3).]

very heat stable and similar to *S aureus* enterotoxin. The diarrheagenic toxin is not heat stable.

The diarrheagenic enterotoxin gives rise to symptoms within 24 hours (25). The organism grows in the intestinal tract, producing the enterotoxin that leads to cramping and watery diarrhea, but rarely nausea. Symptoms usually resolve within 24 hours, except in the elderly in whom the illness may last for weeks. Strains of diarrheagenic *B cereus* are found in foods such as meat products, milk and dairy products, and products made from these items (26).

### Natural Flora of Foods

*B cereus* and *C perfringens* are components of the natural flora of many foods (25,26). These organisms compete with other organisms for available resources, thus somewhat limiting growth. When foods are cooked, most competing microorganisms are killed, but the heat resistance of the spores allows these two spore-formers to survive and grow in a noncompetitive environment. The preventative measure for significant growth of these pathogens is to limit the time that cooked cereals, meats, gravies, and cooked dairy products reside in the temperature abuse critical range. This optimal growth temperature range is from 21°C (70°F) to 49°C (120°F). In this temperature range, doubling time for these organisms is only 7 to 10 minutes and growth leads quickly to the numbers sufficient to induce symptoms of gastroenteritis. Hence, the 2001 Food Code (24) indicates that potentially hazardous foods must be chilled from 60°C (140°F) to 21°C (70°F) in less than 2 hours and then to 5°C (41°F) in less than 4 more hours. Large quantities of food will not reach temperature goals unless divided into smaller amounts or possibly artificially chilled using cold sticks, ice baths, or ice packs.

**Caliciviridae/Norwalk-like Viruses.** Viruses of the family *Caliciviridae* are the leading cause of gastroenteritis in the United States, and possibly the world (1,27-32), and include the Norwalk-like viruses. Ninety percent of the 267 million cases each year in the United States are from unknown causes (28). Several authors have suggested that these are of viral origin (1,28,29). Of the known causes, 80% are viral, with Norwalk-like virus being the most important in both food and other vectors. Of the total food-related illnesses, 67% are of viral etiology with 99% caused by Norwalk-like virus. In their calculations, Mead and colleagues (1) used the figure of 40% of Norwalk-like virus incidence as food-related. More current research using more sensitive detection techniques suggests that the actual viral food-related vectors might be in the 60% range (30).

Unlike bacteria, viruses are difficult to detect in food or stool samples (27,28). As obligate parasites of human cells, their culturing is difficult. Historically, analysis of samples required electron microscopy looking for what were referred to as small round-structured viruses. This procedure was time-consuming, difficult, and resulted in problems with epidemiological surveys. An improvement in detection came with immunological testing of samples, but the genetic diversity of calicivirus and the complexity of the food/feces matrix make this procedure difficult as well (29). More current molecular techniques (reverse

transcriptase-polymerase chain reaction and enzyme-linked immunosorbent assay) are much simpler and easier, allowing for screening of multiple samples simultaneously. This analytical advance has led to faster and more accurate determination of the actual burden of disease caused by calicivirus.

Calicivirus is spread by the fecal-oral route of transmission, with secondary and tertiary transmission by a variety of means. Contaminated surfaces, hands, vomitus, food, and water are possible means of transmission. CDC data indicate that 39% of calicivirus outbreaks were food-related, compared with 12% from person-to-person contact (29). Unlike many bacterial pathogens that require millions of cells to cause illness, the infectious dose of calicivirus seems to be less than 100 viruses (28). Shedding of virus may begin before symptoms of illness (30) and last for 2 weeks after illness (29), important implications for foodservice operations.

Institutions and restaurants are the leading venues of calicivirus outbreaks (30-32), with 45% and 39%, respectively, of outbreaks attributed to these sites. Of particular note is the fact that nursing homes account for 30% of calicivirus outbreaks (31). This population is particularly at risk for death associated with diarrheal diseases such as that caused by calicivirus (33). Some of the largest outbreaks have occurred in the cruise-ship industry (34) and illustrate the difficulty in controlling the spread of illness in a contained environment.

Shedding of the virus through feces or vomitus may occur before the illness is recognized and may continue for 2 weeks after illness. Calicivirus symptoms are acute gastroenteritis with vomiting and diarrhea occurring within 12 to 48 hours after exposure and lasting for up to 5 days. Diarrhea has been reported to continue as long as 28 days (33). The feces and vomitus of ill individuals are infectious, containing large quantities ( $10^5$  or more) of virus. Handling of contaminated bed linens, drinking glasses, and other items touched by ill persons could lead to infection (29).

In foodservice operations, the illness may be spread from worker to worker and to the food. Control in foodservice settings is by exclusion of ill workers for at least 48 to 72 hours, if not longer, and frequent handwashing with soap and water for at least 10 seconds. Because some evidence suggests that the virus may be shed for longer than 72 hours, longer exclusion may be required.

### CRITICAL BEHAVIORS CAN PREVENT ILLNESS

Figure 6 shows the leading factors associated with foodborne-disease outbreaks in the United States. Based on these factors, it is clear that failures in critical behaviors lead to the incidence of food-related illness. Leading causal behaviors are failure to: (a) hold and cool foods appropriately, (b) practice proper personal hygiene, (c) prevent cross-contamination, (d) cook to proper internal temperatures, and (e) procure food from safe sources.

Another critical but often unrecognized food safety factor is the temperature at which potentially hazardous foods are received by food services. Rural stores and foodservices are particularly at risk for poor delivery temperatures. In a 2003 supplement to the 2001 Food Code, the Center for Food Safety and Applied Nutrition (CFSAN) provided temperature standards by which potentially

hazardous foods are to be received (35). Previous editions of the FDA Food Code provide the best temperature standards for preparation, holding, and storage of foods (23). The higher temperature for the “danger zone” has been reduced from 60°C (140°F) to 57°C (135°F) (35).

The impact of Hazard Analysis and Critical Control Point (HACCP) on the meat and poultry industry was recently reviewed by deGraft-Hanson (36). Lethal outbreaks in the 1990s of *E coli* 0157:H7 poisonings from undercooked hamburgers led to the establishment of the HACCP. The availability of diagnostic products and an improvement in the sensitivity of methods used to isolate and confirm the presence of pathogens in foods means that very low numbers can now be detected. The zero tolerance for visible fecal contamination of poultry seems to have reduced the cases of *Salmonella* reported to the CDC. Producers and processors have invested in upgrades to facilities and technology to meet these new standards, and the true impact is yet to be determined (36).

While these contributing factors can be controlled with the use of HACCP and standard of practice programs, employee adherence to standards is essential to ensure safe foods. Management must instill the importance of these behaviors in employees. Focus groups held in three western states with restaurant workers and managers to help identify motivators and barriers to safe food handling practices revealed a shortage of workers trained in safe food-handling procedures and an overall high turnover rate among restaurant employees (37). The managers expressed strong interest in hiring workers trained in food safety and were willing to pay higher wages for trained workers. The welfare-work recipients did not express as strong an interest in the training, perhaps because few considered foodservice work to be an attractive future (38). Youth involved in 4-H (Head, Heart, Hands, Health) programs expressed strong interest in food safety training, favoring field trips, club presentations, and computer training as preferred ways of learning (2).

A recent multistate surveillance for food handling, preparation, and foodborne disease reported data from 12 food safety questions administered in several states as part of the Behavior Risk Factor Surveillance System (39). Approximately 20% reported some high-risk food handling, preparation, and consumption behaviors (such as eating undercooked eggs or pink hamburgers, not washing the cutting board with soap after cutting raw meat, or not washing hands with soap after handling raw meat). In a consumer survey in the South, good food-handling behaviors were associated with being female and married, having a large household, and having modest income and education (40). Better food handling was also associated with recalling seeing safe food-handling labels for meat and poultry. Sources of food safety information were more commonly reported as coming from newspapers rather than mass media, perhaps due to a more positive view of newspaper reporting (40).

#### Technological Advances and Food Safety

Newer packaging and processing techniques such as vacuum sealing, flash chilling or freezing of freshly harvested or processed foods, and food labeling of purchase or use dates (eg, “sell by” and “best used by”) combine to

extend the quality shelf-life of many foods and help consumers recognize safe periods of consumption (35,41-43). Sensors that detect the presence of tyramine or histamine can be packaged with fresh meat products to identify when these amines are being formed, signaling deterioration (44).

#### Protecting Vulnerable Populations

Compliance with guidelines for safe storage time and temperature is essential, but more stringent guidelines may be needed for individuals with compromised immune systems, older individuals who are more vulnerable to viral infections, individuals on certain drug regimens (monoamine oxidase inhibitors), and young children with less gastrointestinal reserve capacity (45). For these individuals, the adage to “buy fresh, cook fresh, and eat fresh” may serve better than simple standard storage times of “use by” dates (45). McCabe and colleagues have proposed a set of more conservative guidelines for vulnerable populations (46). The FDA has recently continued a warning for vulnerable individuals to not consume raw alfalfa sprouts, for example, due to continuing risk of *Salmonella* after several outbreaks in 10 states (47,48). The FDA’s Food Advisory Committee is reviewing recommendations for limiting intake of fish and methylmercury for pregnant women, nursing women, women about to become pregnant, and young children (49).

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Prebiotics and probiotics offer the potential of protecting vulnerable populations from foodborne pathogens. A recent review article suggests that *Lactobacillus acidophilus* inhibits growth of pathogenic bacteria including *Yersinia enterocolitica*, *B cereus*, *E coli*, *L monocytogenes*, *Salmonella*, *Clostridium*, *Staphylococcus*, *Streptococcus*, and *Pseudomonas* (50).

#### KEEPING THE FOOD SUPPLY SAFE

In spite of all that has been written about foodborne disease and its causes, the conclusion is the US food supply remains safe if critical behaviors are observed in food handling. HACCP programming and employee education can control and prevent hazards that are present in the foods, that may form in the foods, or that may be introduced to foods (51). In 2003, new recommendations for food contact by bare hands were specified for potentially hazardous foods (35).

CFSAN has established a new 4-year cycle for the revision of the Food Code, with the next revision due in 2005 (35). Annual supplements to the 2001 Food Code have provided interim updates (35).

Physicians are being provided with new information online about the diagnosis and management of foodborne



disease (52). The Institute of Medicine recently released a report on scientific criteria to ensure the safety of foods, bringing new technology and the application of statistics to sustaining food safety and security (53). The CDC and the Hospital Infection Control Practices Advisory Committee recently provided guidelines for environmental infection control in health care facilities (54). Included in this are general guidelines and steps for cleaning and maintaining ice machines, dispensers, and storage chests.

These publications reflect the increased interest in food safety requirements of the Bioterrorism Act and recognition of the globalization of the food supply (55-57). Foreign food suppliers are now being required to register with the FDA and provide prior notification of food shipments to the United States. The term *food security* is now being used to represent more than freedom from hunger (57). Discussion and new guidance related to full implementation of the Bioterrorism Act can be followed online at the CFSAN Web site.

### Implications for Dietetics Professionals

The traditional focus on meat, eggs, poultry, and milk dishes as the major targets of prevention of foodborne disease must now be expanded to include bottled water and produce such as lettuce, alfalfa and bean sprouts, watermelons, cantaloupe, and strawberries. Careful selection, washing, and separation from raw meat and poultry are all needed to prevent potential foodborne illnesses. Thorough heating of ready-to-eat meat as well as cooking eggs and hamburger meat beyond rare temperature represent additional recommendations to be made to consumers. Temperature guidelines such as "danger zone" charts need to be updated to reflect the new recommendations made by government agencies collaborating to increase food safety. Prompt and appropriate cooling/chilling procedures are essential to keeping bacterial and viral growth to a minimum both in institutional and home kitchens.

Dietetics professionals can take the lead in designing HACCP plans and conducting food safety training. Consumers, young people, and employers are showing increased interest in more education about food safety.

Online government resources allow continuous monitoring of proposed regulations and updating of food safety recommendations. Online access to actions and reports about food safety, food recalls, and food safety guidelines helps dietetics professionals stay knowledgeable and be prepared to meet client, employee, and employer needs.

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